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SOPHISTICATED JAMMERS AND ADAPTIVE ARRAYS

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ABSTRACT

This report describes progress under Naval Air Systems Command Contract N00019-81-C-0093 during the second quarterly period. Research on the behavior of adaptive arrays with sophisticated jammers is summarized.

I. INTRODUCTION

This report describes progress under Naval Air Systems Command Contract N00019-81-C-0093 for the second quarterly period. This contract involves studies on the effectiveness of two types of jamming against adaptive arrays: envelope modulated jammers and cross-polarized jammers. Our progress during the second quarter in these areas is described below.

II. PROGRESS

A. Envelope Modulated Jamming

Studies have been continued in two areas related to envelope modulated jamming.

1. Sinusoidally Modulated Jamming

The effect on array performance of a single jammer with sinusoidally modulated envelope has been evaluated. We have run a large number of curves that show the fractional envelope modulation, envelope peak, and output signal-to-interference-plus-noise ratio (SINR) variation as functions of signal angles of arrival, jammer modulation frequency, desired signal and jammer power, and feedback loop bandwidth. We have also computed the effect of such jamming on bit error probability when the array is used in a digital communication system. For this study, we assumed a differential phase shift keyed (DPSK) desired signal. These curves characterize the effectiveness of such jamming against the adaptive array.

Our results are currently being prepared as a contract report.

2. Eigenvalue Behavior in Adaptive Arrays

Our study of the covariance matrix eigenvalues in adaptive arrays has been completed. A report on this subject was published during the last quarter [1]. This report describes how the number of elements, the element patterns, the element spacings, the signal powers and arrival angles, and the signal bandwidths affect eigenvalue behavior in adaptive arrays.

We were initially interested in this subject in connection with our study of modulated jamming. The reaction of the array to modulated jammers depends on the array speed of response, which is controlled by the eigenvalues of its covariance matrix. However, in the process of this work, we have discovered an interesting relation between the array output SINR and the middle eigenvalue. (With one strong jammer and a weak desired signal, the covariance matrix has a large eigenvalue controlled by the jammer, a middle eigenvalue that depends on the desired signal and array parameters, and some small eigenvalues.) It turns out that the middle eigenvalue (which we call λ_2) and the SINR are always related by

$$\lambda_2 = \text{SINR} + 1 \qquad (1)$$

As the desired signal power, desired signal arrival angle, interference power and interference arrival angle vary, both λ_2 and the SINR vary up and down. In general, however, the variations of λ_2 and the SINR are always tied together by Eq.(1).

This relationship is useful for the following reason. To provide sector coverage with an adaptive array for a communication system, the

designer must choose a set of element patterns that minimize SINR variation as the desired and interference signals scan over the sector of interest. In addition, the designer would also like to minimize variations in array speed of response. Eq.(1) tells us that choosing elements to minimize SINR variation also minimizes variations in the speed of response. The designer does not need to consider SINR and eigenvalue variation separately. Both are minimized at the same time.

B. Cross-Polarized Jamming

During this quarter we have also begun work on adaptive array performance with cross-polarized jamming. By "cross-polarized," we mean a jammer that transmits two independent jamming waveforms on orthogonal polarizations. Such a jammer uses up two degrees of freedom in the array pattern at the same time.

Work on the performance of adaptive arrays with cross-polarized jamming was started under the previous contract, but not completed. During this quarterly period, we have continued this effort. We have obtained a large number of performance curves for a single tripole antenna against cross-polarized jamming. A technical report on this subject is planned.

III. REFERENCES

1. K. J. Suen "A Study of Eigenvalue Behavior in Adaptive Arrays," August 1981, Technical Report 713603-2, The ElectroScience Laboratory, Ohio State University, Columbus, Ohio 43212; prepared under Contract N00019-81-C-0093 for Naval Air Systems Command.